

Photoplethysmography Written Proposal

by Joshua Port

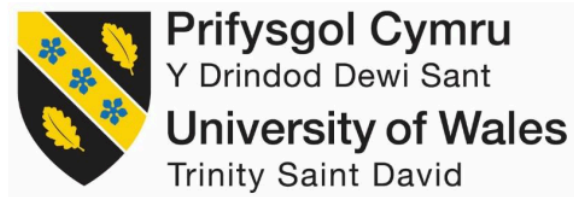
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The Design of a Photoplethysmography (PPG) Monitor and Emergency Services Communication System

by
Joshua J Port

Supervisor: Steve Mosey

Project submitted as part of the requirements for
the award of
BSc (Hons) Computing (stream)
*BEng (Hons) Electrical and Electronics
Engineering*

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Student Name:	Joshua J Port	Student Number:	2114468
Module:	Independent Project	Module Code:	ACCA6020
Project Title:	Photoplethysmography (PPG) Monitor and Emergency Services Communication System.		
Project Tutor:	Steve Mosey		
Word Count	1520		

Photoplethysmography (PPG) Monitor and Emergency Services Communication System

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Aims

The aim of this project is to design a specific, wrist worn, watch which can help to monitor the user's heart rate and send out an alert to the emergency services, should that rate drop below a predetermined critical level. This design will be made due to the current gap in the market for heart rate alert and detection systems. The main problem with the current devices is that the monitor can only send a message to the user's next of kin. This poses a problem to a large number of potential users due to their next of kin being hundreds, if not thousands, of miles away from their location. By enabling the watch to communicate with the emergency services, a higher level protection and life preservation can be put into place. The device will be simplistic in both the use and design aspects allowing an ease of use for all age groups.

Objectives

Objective	How will it be achieved?	What could cause complications?
Decide on a design which has a specific gap within the current market industry.	Extensive background research regarding PPG monitors will be undertaken in order to establish which areas need to be covered to bridge the current gaps in industry.	Areas within this domain are already widely covered, so finding a gap could be quite difficult.
Understand how the Photoplethysmography sensor operates and the calculations to determine the heart rate / blood flow.	A plethora of background information will be obtained from prior research within this domain and books associated with the design. This will be shown in the project's literature review.	Finding niche papers tailored to the areas surrounding this design could pose a challenge. Some website or books could also show fictional information.
Design a functioning software simulation of the design model using a known simulation software.	This will be achieved by choosing a specific programmable integrated chip which can be used with the design, as well as, using a known software.	Choosing the wrong chip could be catastrophic for this model. Also getting the input and output voltages wrong could have a cascading effect to the hardware design.
Design a functioning hardware design model from the simulated design.	This will be achieved by ensuring the simulation software is functioning normally as well as, ordering the materials well ahead of time.	The design could have faulty components. Short circuiting of the devices being used.

Table 1 - Objectives List

Overall, the deliverables for this project will be:

- 1) A software schematic
- 2) A software design
- 3) A hardware schematic
- 4) A hardware design mode. This will look within the realms of a wrist worn smart / sensor watch.
- 5) Two Power Point viva's, to show the development of the project.
- 6) A poster to showcase the overall design and its functionality.

Background to the Project/Literature Review

Photoplethysmography was first explained in the 1930's as the study / measurement of light absorption in a localised area of tissue over a selective period of time [1]. This was done by shining a controlled level of light (lux) through the patient's skin and recording the absorption by checking how much light had been reflected off the blood cells to the sensor. This first design for this technology included a large light and reflector photocell device placed above the back of the hand. Since then, the sensor technology has significantly advanced as well as, shrunk in size to be both wrist worn or finger worn. The advancements of this allow the user to constantly track their health throughout the day without big external equipment. This is widely used by customers who use the gym or want to collect data relating to their specific workout or lifestyle [2].

The current market for these devices consists of brands such as Garmin, Fitbit, Whoop and Polar [3]. These devices are all consistent with the aspect of them being worn on the wrist and being low profile in size. This implies that the project should take more of a step towards device being wrist worn rather than the other options such as, a band across the heart or round the finger. Another factor to be considered is the specified sensor technology used in these designs. The specific technology used is identical to that of a pulse oximeter to which a green light is projected into the skin and the reflected light level (in lux) is measured by an optical sensor [4]. The level of the lux is then taken and placed into a heart rate monitor equation where the finalised level of the users' heart rate can be displayed on a Liquid Crystal Display (LCD) style terminal. The finalised design will consist of some of these previous technologies or modules however, it will have new developmental areas such as a communication link directly to the emergency services through the users' phone.

Device comparison

Question	Whoop	Fitbit	Project Design
Image or Diagram			
Who is the intended audience?	Gym users and customers focused on fitness.	The Fitbit is designed for all user age groups.	The new design will be tailored to all age groups.
How big is the model?	Small and compact	Small and compact	Small and compact
User ease	The whoop is harder to use with an additional payment package being required for operation.	A simplistic use design with no additional charges.	The design will be simple to use and have no additional charges.
Is there a display?	Whoop does not have a display screen.	Most Fitbit models do come with an inbuilt screen.	There will be a small screen integrated into the design.
Will it have phone connectivity?	Yes. The whoop does connect to the user's phone.	The Fitbit does connect to the user's phone.	The design will have connectivity to the user's phone.

Project Design

The first stage of the project will be the simulation design which will incorporate the use of the proteus simulation software and its already inserted components. This simulation will be the first design element to establish the exact value and amount of the specified component which will be required to create a fully functioning hardware design. Proteus will be used due to the familiarity with this software as well as containing all of the required resources for the project.

The product in question will have the capability to monitor the users heart rate using the reflection of light off of the blood vessels back to a photo detector using the equations associated with photoplethysmography. The value of the reflected light will then be placed into the heart rate calculated equation and output the final result onto a small display such as an LCD. The device will have to be small enough for the user to wear it around the wrist and made from comfy materials to avoid any irritation.

The model will be designed using some selective predesigned modules such as the sensor unit and an LCD but in addition to this, the model will also be designed with new concept elements. Shown below is an image of a predesigned sensor model. This sensor unit is the same style unit which will be incorporated into the final design alongside a product specific, predesigned or newly designed, printed circuit board (PCB) with a main programmable integrated chip (PIC) and a Bluetooth module. The Bluetooth module will be responsible for connecting to the users' phone to allow a call to be made to the emergency services.

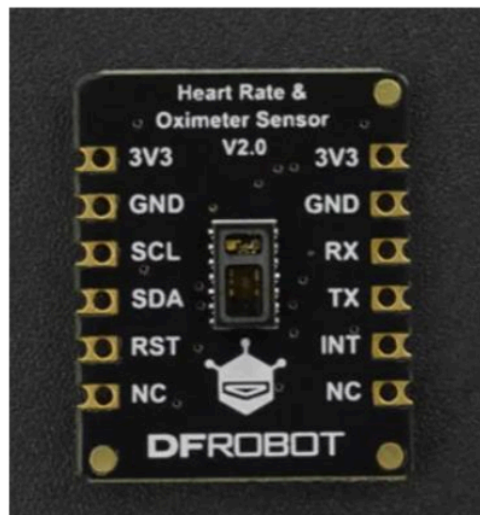


Figure 1 – Sensor Module Example [7]

Shown below here is the type of module which can control the Bluetooth connectivity to the users' phone to ultimately place a call to the respective emergency service required. This is one of the most fundamental aspects of the design due to the nature of what it does.



Figure 2 – Bluetooth Module Example [8]

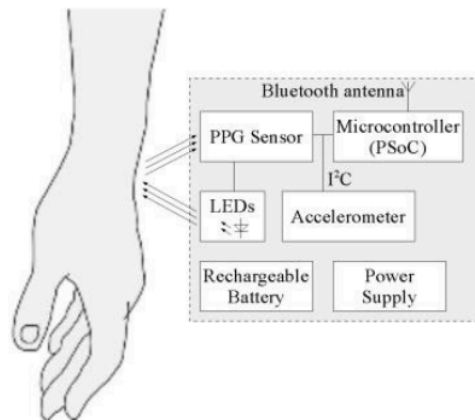


Figure 3 – Diagram on How the Sensor Module and Design Will Work [9]

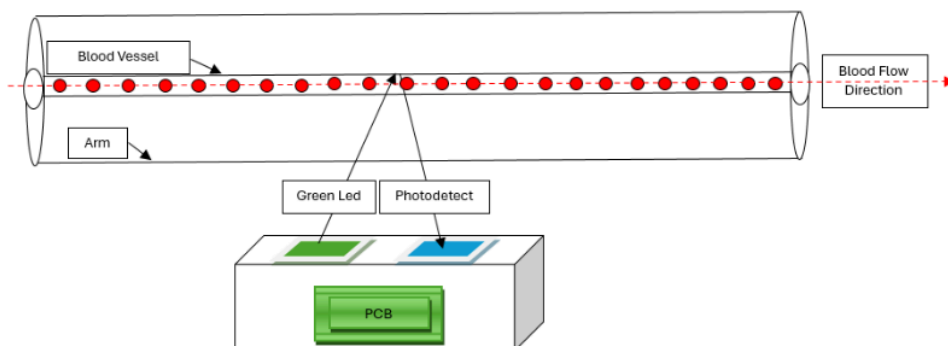


Figure 4 - Visual Representation of the Sensor Working

Figure 3 shows a model of how the project design will be made within the casing of the heart rate monitor. The LED will emit a green light into the skin which will allow the light to be reflected off of the flowing blood cells within the users' blood vessels (Figure 4). This reflected light level will be picked up by a PPG photo detective sensor and the information transferred to the microcontroller via a communications link such as I²C. The device will be battery operated however, the battery will be rechargeable to be firstly; easy to use and secondly, more environmentally friendly. In order to charge the device, A power cable will be run from the socket / USB plug to the device.

Resources

Data about current devices and what users want to see in this project will be determined with a questionnaire. This questionnaire (figure 5) will not ask for any names and will be kept in accordance with the Data Protection Act 2018 and GDPR standards. Before the start of the study, the participants will be asked to read through the information leaflet (figure 6) to ensure they would like to take part in the study and asked for a written signature for consent before starting the questionnaire. This will ensure that all participants are willing to take part in the study and are able to take part.

Shown below in figure 7 is the timeline which has been set out for each element of this project. This is broken down into 5 categories (as shown in the appendix). The first element up until the 28th of October will be preparing the background information and proposal to submit to get approval to continue with the project. Once this has been approved the next 3 months will be designing a software model which will be the baseline for the function of the design. This will require a laptop and the Proteus simulation software. Next will be the hardware design, based off of the simulation, as well as the report. The hardware will be designed at least a month prior to the end of the project to allow corrections if required. The project will close on the 29th of April and the presentation of findings will be set for the 6th of May.

Photoplethysmography (PPG) Questionnaire

Student Name: Joshua J Port Student Number: 2114468

Project Title: Photoplethysmography (PPG) Monitor and Emergency Services Communication System.

Please read and place an x in the box if you agree. Example: ☒

You have read the attached subject information sheet ☐

You give consent for the data collected by this form to be used within the project ☐

Signature of participant

Disclaimer: All data collected in this questionnaire will be stored for later use within the research area of the related project that can only be accessed by the researcher. All data will adhere to the Data Protection Act 2018 and conform to any GDPR laws therein. For this reason, it is asked that the participant of this study is not to write their name on this questionnaire and will remain anonymous throughout the project.

Q No.	The Question	Yes	No	N/A	Other Information
Q1	Do you go to the gym more than once per week?	☐	☐	☐	
Q2	Have you ever worn a PPG / heart rate monitor?	☐	☐	☐	
Q3	If yes to Q2, do you wear the monitor on a daily basis?	☐	☐	☐	
Q4	Are heart rate monitors easy to use?	☐	☐	☐	
Q5	Should a PPG monitor have a screen?	☐	☐	☐	
Q6	Is the best place for a PPG monitor on the wrist?	☐	☐	☐	
Q7	Should the monitor connect to the user's phone?	☐	☐	☐	
Q8	Should you have to pay a subscription to use a heart rate monitor and app?	☐	☐	☐	
Question		Answer			
Q9	Is there anything you would want to see incorporated into a wrist worn PPG sensor?				
Q10	Do you think there are any major problems with current on the market heart rate monitors?				
	Other comments:				

Figure 5 - Photoplethysmography Participant Questionnaire

Participant Information leaflet

Photoplethysmography (PPG) Monitor and Emergency Services Communication System.

Researchers Name:

Joshua J Port

Given to:

Possible Participant

Introduction

You are invited to participate in a research study on developing a next generation photoplethysmography (heart rate) sensor which will contact the emergency services and ping the location when the users heart rate drops below a predetermined level. Participation is not mandatory, and it is completely your choice whether you choose to take part in this study. This questionnaire will not be invasive of any kind and will not require you to disclose any personal information or illnesses you may have or had. This leaflet will disclose to you any information that may be required for you to participate and any risks that may be associated with this study. It will also explain to you what will be asked of you during this study to help you decide if you would like to take part.

Why is this study necessary?

This study is needed to establish what is needed or wanted when designing and producing a Photoplethysmography sensor/watch. This study will also help to understand what aspects are easy to control with a heart rate monitor and what needs to be adapted to suit a wider audience.

Who can take part in this research study

Anyone is able to take part in this study and there are no prerequisites for you to have before or during this study. There is no reason why anyone cannot participate in this study.

Preferred

- Participants who would like to have a look into heart rate monitors.
- Participants who already wear heart rate monitors.
- Participants who are interested in the preservation of life.

None of the preferred prerequisites are mandatory.

Study de-brief

Once the study is complete you will be asked if you would like feedback on your answers and whether you would like to see the finalised product when it is designed. It is your choice if you would like to receive this feedback or view this design and is not mandatory if you participate.

Figure 6 - Photoplethysmography Participant Information Leaflet

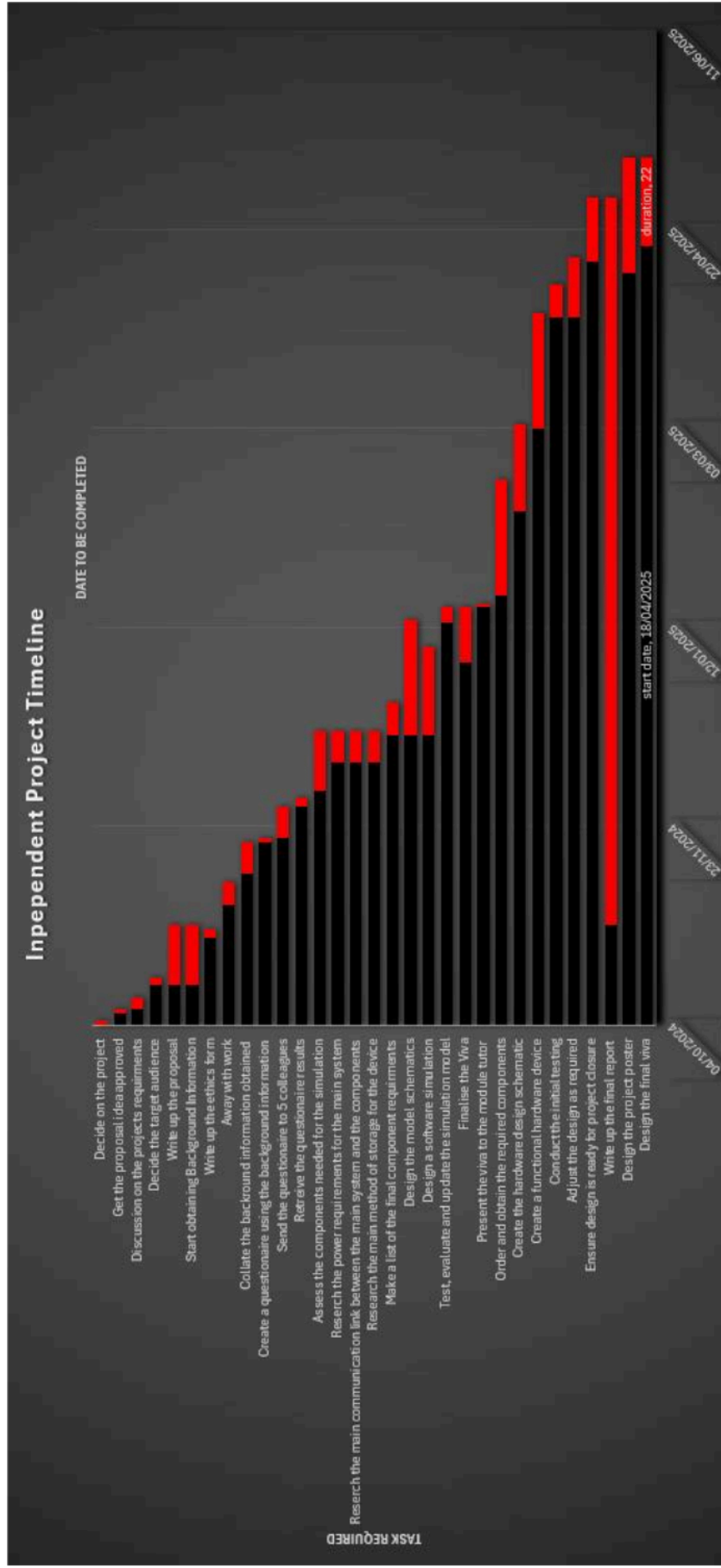


Figure 7 - Project Timeline Gantt Chart

References

- [K. H. S. Aymen A. Alian, "Photoplethysmography," in *Best Practice and Research Clinical Anaesthesiology*, New Haven, Elsevier, 2014, pp. 395 - 406.
1]
- [F. Sartor, G. Papini, L. G. E. Cox and J. Cleland, "Methodological Shortcomings of Wrist-
2 Worn Heart Rate Monitors Validations.," in *Methodological Shortcomings of Wrist-Worn
3 Heart Rate Monitors Validations.*, Canada, Academic Search Premier, 2018, pp.
4 p.e10108-e10108.
5]
- [E. C. Traci Pedersen, "8 Best Heart Rate Monitors in 2024," Healthline, 05 February
6 2024. [Online]. Available: <https://www.healthline.com/health/fitness/heart-rate-monitor>.
7] [Accessed 17 October 2024].
- [C. V. H. a. N. V. H. Neide Simões-Capela, "Heart Rate Estimation From Wrist-Worn
8 Photoplethysmography: A Review," *Heart Rate Estimation From Wrist-Worn
9 Photoplethysmography: A Review*, vol. XIX, no. 16, pp. 1-2, 2019.
10]
- [Whoop, "Whoop Bands," Whoop, 2024. [Online]. Available: https://shop.whoop.com/en-uk/collections/band?order_by=featured. [Accessed 21 October 2024].
11]
- [Google, "Fitbit Charge 6 Tracker," Google, 2024. [Online]. Available:
12 https://store.google.com/product/fitbit_charge_6?hl=en-GB. [Accessed 21 October 2024].
13]
- [DFRobot, "DFRobot Heart Rate And Oximeter Sensor Breakout Board Heart Rate
14 Sensor Breakout Board," RS, 2024. [Online]. Available: [https://uk.rs-
15 online.com/web/p/sensor-development-tools/2473241?cm_mmc=UK-PLA-DS3A-_-
16 google-_-CSS_UK_EN_ePMax_Prio2-_-_-
17 2473241&matchtype=&&gad_source=1&gclid=Cj0KCQjwmt24BhDPArisAJFYKk30oow
18 NIN1e8O9IfiiM2D9pVorbGs8cll-2MdUhi-sy0l79pf5DAW8aAgKNEALw_wcB&gc](https://uk.rs-online.com/web/p/sensor-development-tools/2473241?cm_mmc=UK-PLA-DS3A-_-google-_-CSS_UK_EN_ePMax_Prio2-_-_-2473241&matchtype=&&gad_source=1&gclid=Cj0KCQjwmt24BhDPArisAJFYKk30oowNIN1e8O9IfiiM2D9pVorbGs8cll-2MdUhi-sy0l79pf5DAW8aAgKNEALw_wcB&gc).
19] [Accessed 22 October 2024].
- [RS, "DFRobot DFR0781 Bluetooth Module Bluetooth 5.0," RS Components, 2024.
20 [Online]. Available: <https://uk.rs-online.com/web/p/bluetooth-modules/2473227?gb=s>.
21] [Accessed 24 October 2024].
- [M. W. a. B. Pankiewicz, "Photoplethysmographic Time-Domain Heart Rate Measurement
22 Algorithm for Resource-Constrained Wearable Devices and its Implementation," MDPI,
23] Gdańsk, Poland , 2020.

Appendix

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Element		Task	Start Date	Days Required (inc weekends)	End Date	Days Used	Finalised End Date	On Time Y/N																									
Project Proposal	Decide on the project	04/10/2024	1	04/10/2024	1	04/10/2024	Y																										
	Get the proposal idea approved	07/10/2024	1	07/10/2024	1	07/10/2024	Y																										
	Discussion on the projects requirements	08/10/2024	3	10/10/2024	3	10/10/2024	Y																										
	Decide the target audience	14/10/2024	2	15/10/2024	2	15/10/2024	Y																										
	Write up the proposal	14/10/2024	15	28/10/2024	15	28/10/2024	Y																										
	Start obtaining Background Information	14/10/2024	15	28/10/2024	15	28/10/2024	Y																										
	Write up the ethics form	26/10/2024	2	28/10/2024	2	28/10/2024	Y																										
	Away with work	03/11/2024	6	08/11/2024																													
Course	Collate the background information obtained	11/11/2024	8	18/11/2024																													
Assess the Target Audience	Create a questionnaire using the background information	19/11/2024	1	19/11/2024																													
	Send the questionnaire to 5 colleagues	20/11/2024	8	27/11/2024																													
	Retrieve the questionnaire results	28/11/2024	2	29/11/2024																													
	Assess the components needed for the simulation	02/12/2024	15	16/12/2024																													
Simulation Model Design	Research the power requirements for the main system	09/12/2024	8	16/12/2024																													
	Research the main communication link between the main system and the components	09/12/2024	8	16/12/2024																													
	Research the main method of storage for the device	09/12/2024	8	16/12/2024																													
	Make a list of the final component requirements	16/12/2024	8	23/12/2024																													
	Design the model schematics	16/12/2024	29	13/01/2025																													
	Design a software simulation	16/12/2024	22	13/01/2025																													
	Test, evaluate and update the simulation model	13/01/2025	4	16/01/2025																													
	Finalise the Viva	03/01/2025	14	17/01/2025																													
University	Present the viva to the module tutor	17/01/2025	1	17/01/2025																													
Hardware Model Design	Order and obtain the required components	20/01/2025	29	17/02/2025																													
	Create the hardware design schematic	10/02/2025	22	03/03/2025																													
	Create a functional hardware device	03/03/2025	29	31/03/2025																													
	Conduct the initial testing	31/03/2025	8	07/04/2025																													
	Adjust the design as required	31/03/2025	15	14/04/2025																													
	Ensure design is ready for project closure	14/04/2025	16	29/04/2025																													
Project Finalisation	Write up the final report	29/10/2024	183	29/04/2025																													
	Design the project poster	11/04/2025	29	09/05/2025																													
	Design the final viva	18/04/2025	22	09/05/2025																													

Figure 8 - Table for the Gantt Chart

Photoplethysmography Written Proposal

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

73/100

PROJECT PROPOSAL - ACCA6020 INDEPENDENT PROJECT

Student Josh Port
Mark 73

Intro / A&O (400 words)		
Project title; Identification of a specific problem to be investigated; Well-defined aims and SMART objectives; Explaining why this project is worth doing; Discussion of what the project needs to do in order to be a success; Description any deliverables that will be produced at the end of the project	20	16
Excellent introduction. Clear aims and objectives. Very good clear list of deliverables		

Background to the Project / Literature Review (400 words)		
Description of how the work to be done by in the project relates to the work identified in the literature review; Discussion of any ethical issues raised by the project Identifying what has already been done within the field; Topic familiarity; Brief literature review using appropriate sources – 6-8 journal papers and book chapters rather than just websites; Selection of relevant models & concepts Very good literature review. Good selection of relevant sources. Good survey of the current available products.	20	14
Project Design (500 words)		
Clear statement of which development methods are to be used and why they are appropriate; Clear statement of which tools are to be used and why they are appropriate; Clear description of how data collected will be analysed No statement of development methodology. Minimal list of tools presented but with clear reasoning why they were chosen. – no programming language or PCB design software listed. Good clear	30	19.5

statements of how data will be collected and processed		
Resources / Planning (200 words)		
List of any deliverables; Clear diagram showing both timing and resource use; Completed ethics form; Limited and relevant appendices Clear list of deliverables for the project Completed ethics form. Gantt chart presented with a clear breakdown of all the tasks.	15	11.25
Document Presentation		
Correct spelling, grammar and punctuation; Flow of narrative/fluency; Coherence; Word processed ; Correct use of referencing with bibliography; Strict word limit Generally a very well written and well-presented document.	15	12

TOTAL	100	72. 75

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